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Phytotoxicology Surveillance Investigation
in the Vicinity of Welland Chemical, Sarnia - 1991

Phytotoxicology Section
Air Resources Branch

ARB No. ARB-069-92-Phyto
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Background

Welland Chemical, located on Scott Road in Sarnia, is a manufacturer of anhydrous aluminum chloride. The product is manufactured by passing gaseous chlorine through molten aluminum and precipitating out the desired product. During the removal of the product from the precipitators and in the subsequent handling and packaging, fugitive emissions of the product occur. The product reacts with the moisture in the air to produce hydrochloric acid and aluminum oxide. Complaints of vegetation damage in the immediate vicinity of the company have been documented since 1970.

The Phytotoxicology Section, Ministry of the Environment has carried out vegetation assessment surveys in the vicinity of Welland Chemical Ltd. since 1970 (1). These surveys were conducted continuously from 1978 to 1987 and 1989 (2,3,4,5,6,7,8,9). No surveys were conducted in 1988 or 1990. During the course of each investigation, injury to vegetation has been observed and documented at sites in the vicinity of the company. This injury has been attributed to emissions from Welland Chemical. Injury symptoms, which usually develop in late July, are typical of those induced by chloride. Chemical analysis of collected survey foliage has revealed sharply elevated levels of aluminum and chloride in vegetation located at sites near Welland Chemical.

In compliance with the request from the Ministry's Sarnia office, surveillance activities were continued by the Phytotoxicology Section in 1991. On 10 September 1991, Mr. A. Kuja and Mr. G. Vasiloff of the Phytotoxicology Section visited the area and conducted an investigation in the vicinity of the Welland Chemical plant.

1991 Phytotoxicology Investigation

Foliar Sample Collection

Duplicate samples of bur oak foliage (*Quercus macrocarpa*), were collected at 11 survey sites - all situated within 750 metres of Welland Chemical (see attached Figure). Foliage samples for chemical analysis were collected in accordance with standard Phytotoxicology sampling techniques (10). The 1991 survey sites are the same as those that have been visited since 1978. At each site, indigenous plant species, particulary those sensitive to chloride, were examined for air pollution injury.

All samples were delivered to the Phytotoxicology processing laboratory in Toronto where they were dried and ground. Processed samples were then submitted to the Ministry's Inorganic Trace Contaminants Section, Laboratory Services Branch for chemical analysis. The samples were analyzed for aluminum, chloride, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, sodium, strontium, vanadium and zinc.

Evaluation of Vegetation Injury

At each survey site, indigenous plant species (particularly those with known sensitivity to chloride), were examined for evidence of chloride-type injury symptoms. A summary of the recorded visual observations is provided in Table 1. Chloride-type vegetation injury was observed at only 3 of the 11 survey sites (1, 4 and 7). These three sites were immediately east, north and west of Welland Chemical, respectively. At Site 1, up to 20% (leaf area) terminal, marginal and intercostal injury was observed on green ash, dogwood and basswood. Up to 2% terminal and marginal necrosis was present on bur oak foliage.

At Site 7, up to 15% terminal and marginal necrotic injury was found on bur oak and basswood. North of Welland Chemical, at Site 4, <1% terminal and marginal necrosis was documented on bur oak but up to 25% injury was observed on hawthorn foliage and up to 10% on elm foliage. No chloride-type injury was observed at any of the other survey sites.

Chemical Analysis Results

Chloride

Chloride concentrations in bur oak foliage from 1982 to 1987, 1989 and 1991 have been summarized in Table 2. Analytical results for the remaining elements appear in Tables 3 to 16. Results contained in the tables are the means of the duplicate sample collection and analyses. Chloride results are expressed as percent (%) but results of the other elements are in parts per million (ppm) dry weight. Shown at the base of each table is the Phytotoxicology Upper Limit of Normal (ULN) guideline for rural foliage. The derivation and significance of the ULN guidelines are described in the attached Appendix.

In the 1991 foliage, chloride concentrations above the ULN guideline of 0.15% were found at 6 sites. The highest 1991 concentration (1.00%) was detected in the Site 7 foliage. Concentrations of this magnitude have not be detected since 1982 when 1.18% was found in foliage at Site 1. Similarly, the 1991 mean of 0.46%, (compiled from Sites 1,4,7 and 10), was exceeded only by the previous high of 0.76% in 1982.

Aluminum

Aluminum concentrations found in the 1989 and 1991 bur oak foliage have been listed in Table 3. Compared to 1989, levels of this element in the 1991 foliage increased at 9 of the 12 survey sites, but all were below the ULN guideline of 500 ppm. In particular, the increases which occurred at Sites 4 and 7 were significant. At Site 4, the 1991 concentration was 225 ppm - up from 65 in 1989. Similarly, the 1991 value of 395 ppm was up from 99 ppm in 1989. At these 2 sites, both aluminum and chloride concentrations increased sharply from 1989 to 1991.

Sodium and Iron

Concentrations of sodium and iron detected in the 1989 and 1991 foliage have been summarized in Tables 4 and 5, respectively. Sodium levels in the 1991 foliage were higher than in 1989 at 8 of the 11 survey sites and also exceeded the ULN guideline at 8 sites. The highest 1991 sodium concentration was found at Site 11, but this contamination is attributed to the influence of de-icing salt. With respect to suspected emissions from Welland Chemical, the sodium concentrations were elevated/excessive at sites close to the source, but the contamination gradient was inconsistent. The mean sodium concentration of Sites 1, 4, 7 and 10, rose from 77 ppm in 1989 to 90 ppm in 1991 (Table 4).

Iron concentrations found in the 1989 and 1991 foliage are shown in Table 5. In 1989, no exceedences of the ULN guideline occurred. In 1991, however, iron concentrations exceeded the 500 ppm guideline at Sites 7 (890 ppm) and 8 (720 ppm). In 1991 the mean iron value of Sites 1, 4, 7 and 10 increased to 327 ppm from 130 ppm in 1989. Although the excessive iron concentrations occurred at two sites close to Welland Chemical, the contamination gradient was weak. The high iron concentrations may be associated with materials handling on the adjacent rail line.

Other Elements

Concentrations of nickel, lead, cadmium, manganese, vanadium, cobalt, zinc, strontium, copper, molybdenum and chromium detected in the 1989 and 1991 foliage are shown in Tables 6 - 16, respectively. None of these elements exceeded their respective ULN guidelines in the 1991 foliage. However, nickel, lead, manganese, vanadium, cobalt and copper concentrations in 1991 were all highest at one of the three sites closest to Welland Chemical (1, 4 or 7).

Summary

Welland Chemical in Sarnia is a facility that manufactures anhydrous aluminum chloride. During the recovery and packaging processes, fugitive emissions of the product escape to the environment. The Phytotoxicology Section has monitored the effects of the emissions on vegetation in the vicinity of the chemical plant periodically since 1970.

In 1991, chloride-type vegetation injury was noted at 3 survey sites - all located close to Welland Chemical. The most severe injury occurred at Site 7 - 100 m north of the factory.

Chemical analysis showed that both chloride and aluminum concentrations in sampled bur oak foliage were highest at Site 7. The chloride level of 1.00% was the highest encountered at this location since the inception of vegetation sampling in 1970. As well, concentrations of iron, cobalt, copper, lead, manganese, nickel, strontium and vanadium were also noticeably elevated at this site.

Overall, the sodium and aluminum content in foliage at sites closest to Welland Chemical was higher in 1991 than 1989. With respect to sodium, the mean concentration at Sites 1, 4, 7 & 10 in 1991 was the highest since 1982.

Based on the visual and analytical data, it is concluded that fugitive emissions from the Welland Chemical plant continue to adversely affect vegetation in a relatively small area, mainly to the west, north and east of the factory. Although the main constituents of the emissions are chloride and aluminum, it is possible that Welland Chemical is also a relatively minor source of nickel, lead, manganese, vanadium, iron, cobalt and copper.

TABLE: 1 Observations of Vegetation Examined at Surveillance Sites, in the Vicinity of Welland Chemical, Sarnia - 1991

Survey Site Number	Vegetation Examined	Observations
1	bur oak	up to 2% terminal & marginal necrosis on scattered foliage.
	green ash	up to 20% terminal, marginal & intercostal necrosis on 80% of foliage.
	dogwood	up to 15% terminal, marginal & intercostal necrosis on 95% of foliage.
	basswood	up to 20% terminal, marginal & intercostal necrosis on 90% of foliage.
	sumach	no air pollution injury symptoms.
	wild grape	no air pollution injury symptoms.
	hawthorn	no air pollution injury symptoms.
	elm	no air pollution injury symptoms.
2	bur oak	no air pollution injury symptoms.
	basswood	foliage senescing - no air pollution injury symptoms.
	dogwood	foliage senescing - no air pollution injury symptoms.
	green ash	foliage senescing - no air pollution injury symptoms.
	elm	insect injury and senescence.
	willow	insect injury and senescence.
4	bur oak	<1% terminal & marginal necrosis and senescence.
	elm	2-10% terminal, marginal & intercostal necrosis with chlorotic banding.
	wild currants	<1% terminal & marginal necrosis.
	ash	advanced foliar senescence.
	wild grape	foliage senescent.
	shagbark hickory	no air pollution injury symptoms.
	dogwood	foliage senescent.

cont'd....

TABLE: 1 (cont'd)

Survey Site Number	Vegetation Examined	Observations
5	bur oak	no air pollution injury symptoms.
	wild grape	no air pollution injury symptoms.
	dogwood	foliage senescent.
	green ash	advanced foliar senescence.
	shagbark hickory	insect injury - no air pollution injury symptoms.
	elm	no air pollution injury symptoms.
6	bur oak	foliage senescent - no air pollution injury symptoms.
	green ash	foliage senescent - no air pollution injury symptoms.
	wild grape	foliage senescent - no air pollution injury symptoms.
	elm	insect injury - no air pollution injury symptoms.
7	bur oak	up to 15% terminal & marginal necrosis plus senescence.
	basswood	up to 15% terminal & marginal necrosis with intercostal chlorotic banding plus senescence.
	wild grape	foliage senescent - no air pollution injury symptoms.
	green ash	<1% terminal necrosis.
	dogwood	advanced foliar senescence.
8	bur oak	<1% terminal & marginal necrosis plus senescence.
	green ash	insect injury and foliar senescence.
	dogwood	foliage senescent - no air pollution injury symptoms.
	wild grape	foliage senescent - no air pollution injury symptoms.
	basswood	foliage senescent - no air pollution injury symptoms.

cont'd...

TABLE: 1 (cont'd)

Survey Site Number	Vegetation Examined	Observations
9	bur oak	foliage senescent - no air pollution injury symptoms.
	dogwood	foliage senescent - no air pollution injury symptoms.
	wild raspberry	no air pollution injury symptoms.
	shagbark hickory	foliage senescent - no air pollution injury symptoms.
	ironwood	no air pollution injury symptoms.
10	bur oak	foliage senescent - no air pollution injury symptoms.
	green ash	foliage senescent - no air pollution injury symptoms.
	dogwood	foliage senescent - no air pollution injury symptoms.
	wild grape	foliage senescent - no air pollution injury symptoms.
	hawthorn	insect injury - no air pollution injury symptoms.
	wild cherry	no air pollution injury symptoms.
11	bur oak	foliage senescent - no air pollution injury symptoms.
	green ash	foliage senescent - no air pollution injury symptoms.
	wild grape	foliage senescent - no air pollution injury symptoms.
	elm	insect injury - no air pollution injury symptoms.
12	bur oak	foliage senescent - no air pollution injury symptoms.
	wild grape	foliage senescent - no air pollution injury symptoms.
	dogwood	foliage senescent - no air pollution injury symptoms.

TABLE: 2

Chloride Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1982-1991

Survey Site Number	1982	1983	1984	1985	1986	1987	1989	1991
1	1.18	0.33	0.38	0.31	0.61	0.36	0.39	0.22
2	0.11	0.08	0.08	0.10	0.13	0.07	0.06	0.12
4	0.42	0.39	0.23	0.37	0.34	0.53	0.22	0.55
5	0.36	0.32	0.18	0.23	0.24	0.28	0.18	0.26
6	0.09	0.10	0.11	0.12	0.15	0.17	0.04	0.14
7	0.82	0.49	0.23	0.34	0.25	0.52	0.32	1.00
8	0.06	0.05	0.07	0.04	0.06	0.08	0.05	0.03
9	0.07	0.02	0.05	0.05	0.05	0.04	0.01	0.03
10	0.60	0.27	0.27	0.43	0.25	0.30	0.19	0.07
11	0.31	0.19	0.20	0.26	0.19	0.14	0.18	0.26
12	0.24	0.13	0.13	0.09	0.12	0.11	0.17	0.17
Mean of Sites 1,4,7&10	0.76	0.37	0.28	0.36	0.36	0.43	0.28	0.46

Phytotoxicology Upper Limit of Normal for Rural Foliage is 0.15%.

[1] Data are percent (%) - dry weight.

TABLE: 3 Aluminum Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Aluminum (ppm - dry weight) 1989	Aluminum (ppm - dry weight) 1991
1	150 m E	120	85
2	350 m E	37	61
4	175 m N	65	225
5	275 m N	58	59
6	425 m N	25	74
7	100 m W	99	395
8	350 m WSW	31	70
9	600 m WSW	30	59
10	400 m S	170	57
11	700 m S	105	80
12	900 m S	54	115
Upper Limit of Normal (ULN) Guideline for Rural Foliage		500	500
Mean of Sites 1,4,7 & 10		114	191

[1] Data are the mean of duplicate sample analysis results.

TABLE: 4 Sodium Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Sodium (ppm - dry weight) 1989	Sodium (ppm - dry weight) 1991
1	150 m E	112	70
2	350 m E	18	32
4	175 m N	49	86
5	275 m N	39	68
6	425 m N	13	54
7	100 m W	79	104
8	350 m WSW	29	31
9	600 m WSW	44	37
10	400 m S	66	101
11	700 m S	280	140
12	900 m S	115	82
Upper Limit of Normal (ULN) Guideline for Rural Foliage		50	50
Mean of Sites 1,4,7 & 10		77	90

[1] Data are the mean of duplicate sample analysis results.

TABLE: 5 Iron Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Iron (ppm - dry weight)	
		1989	1991
1	150 m E	114	102
2	350 m E	80	88
4	175 m N	110	200
5	275 m N	98	110
6	425 m N	76	120
7	100 m W	195	890
8	350 m WSW	120	720
9	600 m WSW	99	113
10	400 m S	101	115
11	700 m S	110	100
12	900 m S	90	185
Upper Limit of Normal (ULN) Guideline for Rural Foliage		500	500
Mean of Sites 1,4,7 & 10		130	327

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[1] Data are the mean of duplicate sample analysis results.

TABLE: 6 Nickel Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Nickel (ppm - dry weight) 1989	Nickel (ppm - dry weight) 1991
1	150 m E	0.9	2.2
2	350 m E	0.8	2.0
4	175 m N	0.9	2.2
5	275 m N	0.8	2.4
6	425 m N	<0.6	2.7
7	100 m W	0.8	3.4
8	350 m WSW	<0.6	2.3
9	600 m WSW	<0.6	1.8
10	400 m S	<0.6	2.4
11	700 m S	<0.6	2.4
12	900 m S	<0.6	2.0
Upper Limit of Normal (ULN) Guideline for Rural Foliage		5	5
Mean of Sites 1,4,7 & 10		0.8	2.6

[1] Data are the mean of duplicate sample analysis results.

TABLE: 7 Lead Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Lead (ppm - dry weight)	
		1989	1991
1	150 m E	1.1	1.7
2	350 m E	<0.5	1.7
4	175 m N	0.9	1.7
5	275 m N	1.0	1.8
6	425 m N	0.7	1.3
7	100 m W	0.8	3.2
8	350 m WSW	0.6	1.1
9	600 m WSW	<0.5	0.9
10	400 m S	0.8	1.7
11	700 m S	1.3	1.4
12	900 m S	0.5	1.3
Upper Limit of Normal (ULN) Guideline for Rural Foliage		30	30
Mean of Sites 1,4,7 & 10		0.9	2.1

[1] Data are the mean of duplicate sample analysis results.

TABLE: 8 Cadmium Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Cadmium (ppm - dry weight) 1989	Cadmium (ppm - dry weight) 1991
1	150 m E	<0.1	0.2
2	350 m E	<0.1	0.1
4	175 m N	<0.1	0.1
5	275 m N	<0.1	0.1
6	425 m N	<0.1	0.1
7	100 m W	<0.1	0.1
8	350 m WSW	<0.1	0.1
9	600 m WSW	<0.1	0.1
10	400 m S	<0.1	0.2
11	700 m S	<0.1	<0.1
12	900 m S	<0.1	0.1
Upper Limit of Normal (ULN) Guideline for Rural Foliage		1	1
Mean of Sites 1,4,7 & 10		<0.1	0.15

[1] Data are the mean of duplicate sample analysis results.

TABLE: 9 Manganese Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Manganese (ppm - dry weight) 1989	1991
1	150 m E	51	39
2	350 m E	77	34
4	175 m N	46	73
5	275 m N	36	32
6	425 m N	27	11
7	100 m W	58	150
8	350 m WSW	67	130
9	600 m WSW	86	54
10	400 m S	73	46
11	700 m S	23	28
12	900 m S	45	110
Upper Limit of Normal (ULN) Guideline for Rural Foliage		NE	NE
Mean of Sites 1,4,7 & 10		57	77

[1] Data are the mean of duplicate sample analysis results.

NE - ULN guideline for this element has not been established.

TABLE: 10 Vanadium Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Vanadium (ppm - dry weight)	
		1989	1991
1	150 m E	0.9	<0.5
2	350 m E	<0.5	0.9
4	175 m N	<0.5	0.8
5	275 m N	0.7	0.5
6	425 m N	<0.5	0.5
7	100 m W	0.8	1.7
8	350 m WSW	<0.5	0.8
9	600 m WSW	<0.5	0.7
10	400 m S	0.5	0.6
11	700 m S	0.7	0.5
12	900 m S	0.6	0.8
Upper Limit of Normal (ULN) Guideline for Rural Foliage		5	5
Mean of Sites 1,4,7 & 10		0.7	0.9

[1] Data are the mean of duplicate sample analysis results.

TABLE: 11 Cobalt Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Cobalt (ppm - dry weight) 1989	Cobalt (ppm - dry weight) 1991
1	150 m E	0.3	<0.2
2	350 m E	0.4	<0.2
4	175 m N	<0.2	0.3
5	275 m N	<0.2	0.2
6	425 m N	<0.2	0.2
7	100 m W	0.3	0.4
8	350 m WSW	<0.2	0.3
9	600 m WSW	0.3	0.2
10	400 m S	<0.2	<0.2
11	700 m S	<0.2	0.2
12	900 m S	0.2	0.2
Upper Limit of Normal (ULN) Guideline for Rural Foliage		2	2
Mean Sites 1,4,7 & 10		0.25	0.28

[1] Data are the mean of duplicate sample analysis results.

TABLE: 12 Zinc Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Zinc (ppm - dry weight) 1989	Zinc (ppm - dry weight) 1991
1	150 m E	22	19
2	350 m E	14	17
4	175 m N	21	19
5	275 m N	37	38
6	425 m N	19	24
7	100 m W	23	35
8	350 m WSW	18	19
9	600 m WSW	18	14
10	400 m S	27	24
11	700 m S	18	19
12	900 m S	16	28
Upper Limit of Normal (ULN) Guideline for Rural Foliage		250	250
Mean of Sites 1,4,7 & 10		23	24

[1] Data are the mean of duplicate sample analysis results.

TABLE: 13 Strontium Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Strontium (ppm - dry weight) 1989	Strontium (ppm - dry weight) 1991
1	150 m E	12	12
2	350 m E	10	71
4	175 m N	21	9
5	275 m N	10	15
6	425 m N	3	18
7	100 m W	15	24
8	350 m WSW	13	22
9	600 m WSW	11	13
10	400 m S	9	12
11	700 m S	13	14
12	900 m S	15	10
Upper Limit of Normal (ULN) Guideline for Rural Foliage		NG	NG
Mean of Sites 1,4,7 & 10		14	14

[1] Data are the mean of duplicate sample analysis results.

NG - ULN guideline for this element has not been established.

TABLE: 14 Copper Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Copper (ppm - dry weight) 1989	Copper (ppm - dry weight) 1991
1	150 m E	5	5
2	350 m E	5	4
4	175 m N	6	4
5	275 m N	6	4
6	425 m N	6	5
7	100 m W	6	7
8	350 m WSW	6	5
9	600 m WSW	6	5
10	400 m S	5	4
11	700 m S	5	4
12	900 m S	5	5
Upper Limit of Normal (ULN) Guideline for Rural Foliage		20	20
Mean of Sites 1,4,7 & 10		5.5	5

[1] Data are the mean of duplicate sample analysis results.

1989 data have been rounded off to nearest whole number.

TABLE: 15 Molybdenum Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Molybdenum (ppm - dry weight)	
		1989	1991
1	150 m E	1.7	0.6
2	350 m E	1.3	0.9
4	175 m N	1.0	0.9
5	275 m N	1.1	0.7
6	425 m N	0.9	0.8
7	100 m W	1.3	0.9
8	350 m WSW	1.0	1.0
9	600 m WSW	0.6	1.2
10	400 m S	2.2	0.7
11	700 m S	1.1	0.7
12	900 m S	0.9	0.3
Upper Limit of Normal (ULN) Guideline for Rural Foliage		1.5	1.5
Mean of Sites 1,4,7 & 10		1.6	0.8

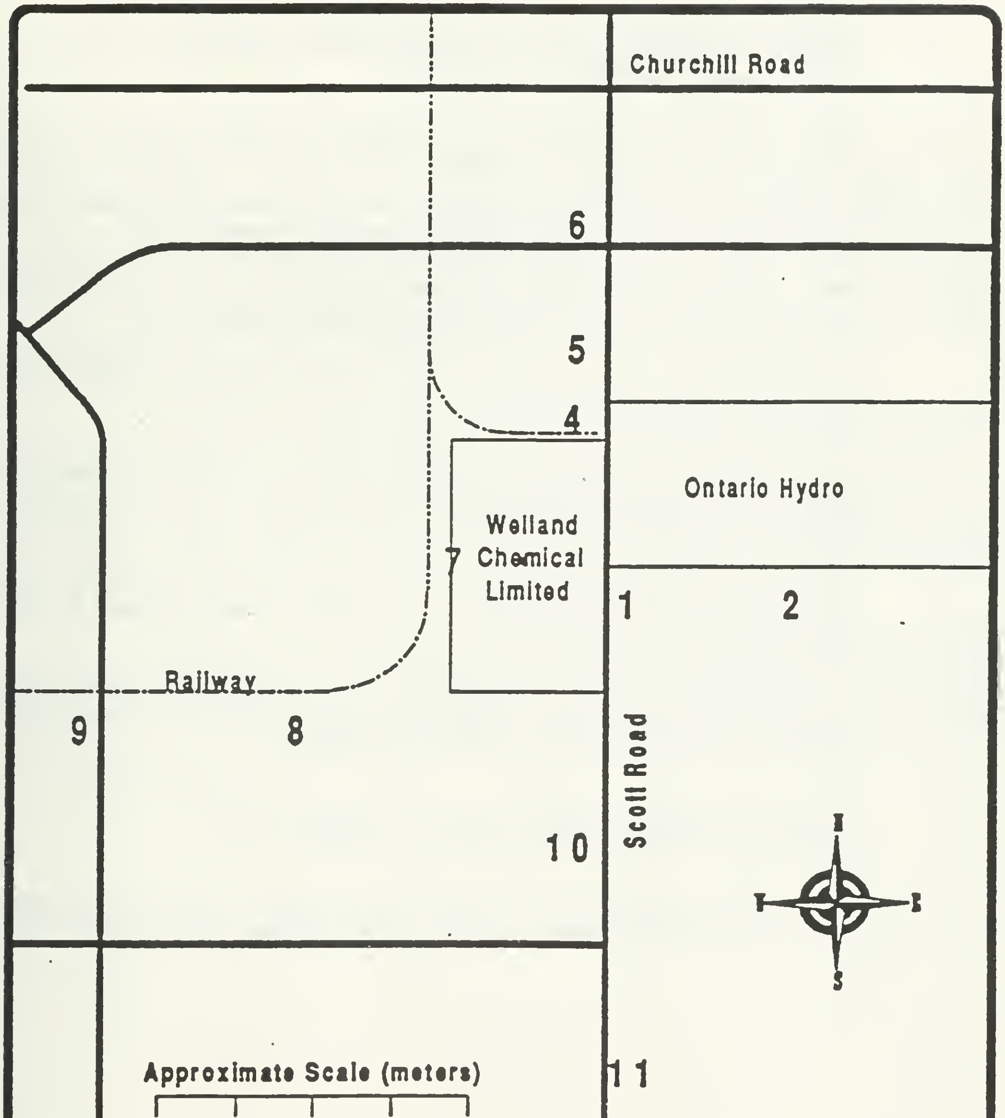
[1] Data are the mean of duplicate sample analysis results.

TABLE: 16 Chromium Concentrations[1] in Unwashed Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia. 1989 and 1991

Survey Site Number	Approximate Distance & Direction from Welland Chemical	Chromium (ppm - dry weight)	
		1989	1991
1	150 m E	<0.5	0.2
2	350 m E	<0.5	0.1
4	175 m N	0.6	0.1
5	275 m N	0.5	0.1
6	425 m N	0.5	0.1
7	100 m W	1.5	0.1
8	350 m WSW	0.9	0.1
9	600 m WSW	0.5	0.1
10	400 m S	<0.5	0.2
11	700 m S	0.5	<0.1
12	900 m S	0.7	0.1
Upper Limit of Normal (ULN) Guideline for Rural Foliage		8	8
Mean of Sites 1,4,7 & 10		0.8	0.2

[1] Data are the mean of duplicate sample analysis results.

Map Showing the Locations of Phytotoxicology Surveillance Sites in the Vicinity of Welland Chemical, Sarnia.



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APPENDIX

Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and/or snow from areas of Ontario not subject to the influence of point source emissions. "Urban" guidelines are based upon samples collected from centres of minimum 10,000 population. "Rural" guidelines are based upon samples collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normsl, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.